6-MERCAPTO-CYCLODEXTRIN DERIVATIVES:REVERSAL AGENTS FOR DRUG-INDUCED NEUROMUSCULAR BLOCK

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

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The invention relates to 6-mercapto-cyclodextrin derivatives, to their use for the preparation of a medicament for the reversal of drug-induced neuromuscular block, and to a kit for providing neuromuscular block and its reversal.

A neuromuscular blocking agent (NMBA, also called a muscle relaxant) is routinely used during the administration of anaesthesia to facilitate endotracheal intubation and to allow surgical access to body cavities, in particular the abdomen and thorax, without hindrance from voluntary or reflex muscle movement. NMBAs are also used in the care of critically-ill patients undergoing intensive therapy, to facilitate compliance with mechanical ventilation when sedation and analgesia alone have proved inadequate, and to prevent the violent muscle movements that are associated with electroconvulsive therapy treatment.

Based on their mechanisms of action, NMBAs are divided into two categories: depolarizing and non-depolarizing. Depolarizing neuromuscular blocking agents bind to nicotinic acetylcholine receptors (nAChRs) at the neuromuscular junction in a way similar to that of the endogenous neurotransmitter acetylcholine. They stimulate an initial opening of the ion channel, producing contractions known as fasciculations. However, since these drugs are broken down only relatively slowly by cholinesterase enzymes, compared to the very rapid hydrolysis of acetyl-choline by acetylcholinesterases, they bind for a much longer period than acetylcholine, causing persistent depolarization of the end-plate and hence a neuromuscular block. Succinylcholine (suxamethonium) is the best known example of a depolarizing NMBA.

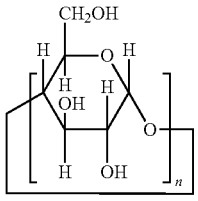
Non-depolarizing neuromuscular blocking agents compete with acetylcholine for binding to muscle nAChRs, but unlike depolarizing NMBAs, they do not activate the channel. They block the activation of the channel by acetylcholine and hence prevent cell membrane depolarization, and as a result, the muscle will become flaccid. Most of the clinically-used NMBAs belong to the non-depolarizing category. These include tubocurarine, atracurium, (cis) atracurium, mivacurium, pancuronium, vecuronium, rocuronium and rapacuronium (Org 9487).

At the end of surgery or a period of intensive care, a reversal agent of NMBAs is often given to the patient to assist the recovery of muscle function. Most commonly used reversal agents are inhibitors of acetylcholinesterase (AChE), such as neostigmine, edrophonium and pyridostigmine. Because the mechanism of action of these drugs is to increase the level of acetylcholine at the neuromuscular junction by inhibiting the breakdown of acetylcholine, they are not suitable for reversal of depolarizing NMBAs such as succinylcholine. The use of AChE inhibitors as reversal agents leads to problems with selectivity, since neurotransmission to all synapses (both somatic and autonomic) involving the neurotransmitter acetylcholine is potentiated by these agents. This non-selectivity may lead to many side-effects due to the non-selective activation of muscarinic and nicotinic acetylcholine receptors, including bradycardia, hypotension, increased salivation, nausea, vomiting, abdominal cramps, diarrhoea and bronchoconstriction. Therefore in practice, these agents can be used only after or together with the administration of atropine (or glycopyrrolate) to antagonize the muscarinic effects of acetylcholine at the muscarinic receptors in the autonomic parasympathetic neuro-effector junctions (e.g. the heart). The use of a muscarinic acetylcholine receptor (mAChR) antagonist such as atropine causes a number of side-effects, e.g., tachycardia, dry mouth, blurred vision, difficulties in emptying the bladder and furthermore may affect cardiac conduction.

A further problem with anticholinesterase agents is that residual neuro-muscular activity must be present (>10% twitch activity) to allow the rapid recovery of neuromuscular function. Occasionally, either due to hyper-sensitivity of the patient or accidental overdose, administration of NMBAs can cause complete and prolonged block of neuromuscular function ("profound block"). At present, there is no reliable treatment to reverse such a 'profound block'. Attempts to overcome a 'profound block' with high doses of AChE inhibitors has the risk of inducing a "cholinergic crisis", resulting in a broad range of symptoms related to enhanced stimulation of nicotinic and muscarinic receptors.

In European Patent Application 99,306,411 (AKZO NOBEL N.V.) the use of chemical chelators (or sequestrants) as reversal agents has been disclosed. Chemical chelators capable of forming a guest-host complex for the manufacture of a medicament for the reversal of drug-induced neuromuscular block were described. The use of chemical chelators as reversal agents for NMBAs has the advantage that they are effective in reversing the action of both depolarizing and non-depolarizing NMBAs. Their use does not increase the level of acetylcholine and therefore they produce fewer side effects and none associated with the stimulation of muscarinic and nicotinic receptors seen with the AChE reversal agents. In addition, there is no need for the combined use of an AChE inhibitor and a mAChR antagonist (e.g., atropine), while the chemical chelators may further be safely employed for the reversal of 'profound block'. Examples of such chemical chelators, as disclosed in EP 99,306,411, were selected from various classes of, mostly cyclic, organic compounds which are known for their ability to form inclusion complexes with various organic compounds in aqueous solution, e.g. cyclic oligosaccharides, cyclophanes, cyclic peptides, calixarenes, crown ethers and aza crown ethers.

The cyclodextrins,



n = 6-9

a class of cyclic molecules containing six or more α-D-glucopyranose units linked at the 1,4 positions by α-linkages as in amylose, and derivatives thereof, were identified in EP 99306411 as particularly useful in the reversal of many of the commonly used neuromuscular blocking agents, or muscle relaxants, such as rocuronium, pancuronium, vecuronium,